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## **Production factor returns : the role of factor utilisation**

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# **Production factor returns: the role of factor utilisation**

Gilbert Cette<sup>a</sup>, Nicolas Dromel<sup>b</sup>, Rémy Lecat<sup>c\*</sup>, Anne-Charlotte Paret<sup>d</sup>

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a: Banque de France and Université de la Méditerranée (DEFI) [gilbert.cette@banque-france.fr]

b: Paris School of Economics, CNRS [nicolas.dromel@parisschoolofeconomics.eu]

c: Banque de France [remy.lecat@banque-france.fr]

d: Banque de France, ENSAE [anne.charlotte.paret@ensae.fr]

\*: Corresponding author.

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### **Résumé:**

Des rendements d'échelle croissants à court terme sont en général mis en évidence par les études empiriques. Ceci pourrait provenir de variables omises, en particulier l'intensité d'utilisation des facteurs de production. Grâce à une base de données d'entreprises (1992-2008) originale, nous montrons que les rendements croissants disparaissent quand le temps de travail, les capacités d'utilisation et surtout la durée d'utilisation des équipements sont introduites dans la fonction de production.

**Keywords:** Fonction de production, productivité, rendement d'échelle

**JEL Classification:** D22, D24, E22, O40

### **Abstract:**

Short-term increasing returns to production factors are usually found in empirical studies. We argue they can be due to omitted variables, particularly the intensity of factor utilisation. Thanks to original French firm-level data (1992-2008), we show how increasing returns to scale disappear when working time, capacity utilisation rate and mainly capital operating time are introduced in the production function.

**Keywords:** Production function, productivity, factor returns

**JEL Classification:** D22, D24, E22, O40

## 1. Introduction

Since the early 1960s, numerous papers have been devoted to estimating the short-term increasing returns to production factors, on macro or micro data (see, for instance, Brechling 1965, Brechling and O'Brien 1967, Smyth and Ireland 1967, Ireland and Smyth 1970, or Hall 1988, 1990). As Solow (1973) underlined, an explanation for apparent increasing returns could lie in the omission of some productive factors in the production function, particularly the degrees of factor utilisation. These degrees would change easily in the short-run (i.e. within the business cycle), while the stock of production factors such as labour and (even more) capital would change more slowly, since the adjustment costs of utilisation degrees are much lower than those of input stocks. Indeed, following a positive or a negative demand shock, firms would only progressively adjust labour and capital to their optimal level, yet would instantly adjust factor utilisation. However, this explanation has been difficult to test, because of a shortage in effective measurement for factor utilisation (see, for example, Abou, Cette and Mairesse, 1990, and for a survey Shapiro, 1986). Initiated by Nadiri and Rosen (1969) on US macro data, some attempts have been made to estimate a factor demand model combining the stock of production factors with their utilisation degrees. But in spite of their neat theoretical specification, these analyses were not empirically satisfying, again because of difficulties in measuring factor utilisation.

Shapiro (1993) brought a considerable progress to this literature. Through the US Census's Survey of Plant Capacity, he obtained a suitable measure for the capital workweek at the micro level,<sup>1</sup> that he merged with usual industry-level data providing measures for output, labour and capital stocks, and total factor productivity (TFP hereafter, calculated with the usual Solow residual approach). This allowed him to articulate, on the period (1978-1988) and at the industry level, changes in TFP, factor volumes and the capital workweek. His empirical results were very instructive. First, the workweek of capital appears to be highly pro-cyclical. Second, apparent factor returns would not be significantly different from zero as changes in the capital workweek are taken into account. Moreover, "*The cyclicity of conventionally measured total factor productivity results, in large part, from variations in the workweek of capital that accompanies increases in other inputs*" (Shapiro 1993, p. 232). Basu (1996) used changes in the input of materials relative to measured capital and labour as an index for unobserved cyclical factor utilisation.<sup>2</sup> Controlling for cyclical utilisation through this proxy, he found no evidence of increasing returns to scale in production (his estimates actually indicated strongly diminishing returns to scale).<sup>3</sup> In an industry-level estimation, Oulton (1996) finds evidence of constant returns to scale, when controlling for aggregate input in manufacturing. However, he questions the fact that cyclical utilisation of factors could solely account for the role of aggregate input: indeed, as put forward by Caballero and Lyons (1992), externalities operating at the level of aggregate manufacturing may be at play as the aggregate input coefficient is stronger when recession periods are removed from the estimation.

A persistent lack of *direct* data on factor utilisation at the *firm* level,<sup>4</sup> regarding particularly the capital workweek, made difficult to assess more precisely the role of factor utilisation in production factor returns. The present paper is an attempt to fill this gap. It benefits from original and rich French

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<sup>1</sup> A description of the measurement of the workweek of capital from this survey is given by Foss (1997).

<sup>2</sup> Same intuition is behind the use of firm electricity consumption data as a proxy for factor utilization by Jorgenson and Griliches (1967).

<sup>3</sup> Greenwood *et al.* (1988) provided an early real business cycle model with variable utilization. The contribution of factor utilization to cyclical productivity is also analysed in Shapiro (1986, 1996), Burnside *et al.* (1995), Basu and Fernald (1997).

<sup>4</sup> This lack of data has been stressed in several analyses, as for example Anxo *et al.* (1995) or Delsen *et al.* (2007, 2009).

individual data on factor utilisation. Precisely, our empirical analysis merges two firm-level annual datasets constructed by the Banque de France: FiBEn and a survey on factor utilisation. FiBEn is a large annual database built on fiscal documents, allowing for instance to calculate firm-level value added, capital and employment. The survey on factor utilisation directly asks plants for their working time, their rate of capacity utilisation and their change in capital operating time with respect to the previous year. The merger between these two datasets results in an unbalanced panel of 10,463 observations over 1992-2008. In our knowledge this panel is unique in containing such rich information, which allows for an original appraisal of factor returns.

As a matter of fact, unobserved productivity shocks or demand shocks may affect input levels and factor utilisation. We deal with this endogeneity issue using instrumental variables, with a careful identification strategy.

Our main empirical results can be summarized as follows: i) Changes in factor utilisation do explain short-run increasing factor returns. When changes in the three degrees (working time, capital workweek and capacity utilisation rate) are taken into account, increasing returns disappear ; ii) Changes in capital workweek contribute more than changes in working time and in the capacity utilisation rate to this result ; iii) Our findings are confirmed by several robustness checks. Altogether, these results further develop on *firm-level* data the early insights of Shapiro (1993) or Basu (1996), with a careful handling of endogeneity. And in contrast with Basu (1996), we use *direct* factor utilisation degrees measurement.

The paper is organised as follow. Section 2 presents our data. Section 3 presents the two models- with an without factor utilisation- and estimation strategy. Section 4 presents the results and robustness checks. Section 5 concludes.

## 2. Data and factor utilisation measures

Our empirical analysis merges two firm-level annual datasets constructed by the Banque de France: FiBEn and a survey on factor utilisation degrees (FUDS, hereafter).

FiBEn is a large database built on fiscal documents, including balance sheets and profit-and-loss statements. It features all French firms with sales exceeding 750,000€ per year, or with a credit outstanding higher than 380,000€. Every year, these accounting data are available for about 200,000 firms. In 2004, FiBEn was covering 80 % of the firms with 20 to 500 employees, and 98 % of those employing more than 500 employees. This database allows calculating firm-level value added ( $Q$ ), capital ( $K$ ) and employment ( $L$ ) volumes:

- The value added volume ( $Q$ ) is calculated by dividing value added in value (production in value minus intermediate consumptions) by a national accounting index of value added price at the industry level (two digit decomposition level).
- The volume of capital ( $K$ ) sums gross capital volumes for buildings and equipment. Gross capital at historical price (as reported in FiBEn) is divided by a national index for investment price, lagged with the mean age of gross capital (itself calculated from the share of depreciated capital in gross capital, at historical price). This measure corresponds to the volume of capital in fiscal reports, usually by the end of a fiscal year. For this reason, we introduce a one-year lag for capital to calculate share-weighted factor growth.
- The average employment level ( $L$ ) is directly available in FiBEn.

The FUDS has been carried out each September since 1989. 1,500 to 2,500 plants<sup>5</sup> are covered by this survey, depending on the year. This dataset directly provides for each plant the annual growth rate of capital workweek ( $WK$ ), the level of labour workweek ( $WL$ ), and indirectly the production capacity utilisation rate ( $CU$ ). From now on, we denote by  $\Delta z$  the growth rate of a variable  $Z$ ,  $\Delta$  being the first difference operator, and lower case variables standing for log values.

- Data on the annual growth rate of capital workweek ( $\Delta wk$ ) stem from the question: “*What is the past evolution, over the last twelve months, of your productive equipment operating time, in percentage?*” A notice attached to the survey explains that productive operating time refers to a specific September full week.
- Data on the level of labour workweek ( $WL$ ) stem from the question: “*What is the average usual working time of your employees in hours during the specific poll week ...*” and the same specific week as for capital workweek is specified.
- One question in the survey asks “*What is the potential percentage of production increase which would be feasible for your plant without any change in your equipment (possibly augmenting the number of employees and working time if it is worthy consistent with public regulations, but without any modification in the shift work organisation)?*”. We denote this data by  $CA$ , and compute the capacity utilisation rate  $CU$  as follows:  $CU = 1 / (100 + CA)$ .

The survey also gives information on the level of employment ( $L$ ) and percentage of employees organised in shift work ( $SW$ ).

While the FUDS is carried out at the plant level, FiBEn gives information at the firm level. A difficulty in the data merge lies in the fact that some firms are multi plants. When several plants of a single firm were covered by the FUDS, we aggregated for each year all plants of this firm, weighting them by their share in the firm’s total employment. We considered the FUDS answers to be representative enough when the employment level corresponding to this aggregation was higher than 50 % of the one reported in FiBEn (otherwise, the firm was dropped from the final dataset<sup>6</sup>). Each time one observation was missing for a given firm, we interpolated its value taking the average of its one-period past and one-period next observations. These imputations concerned 1,036 observations. After this data pre-processing, we obtained 10,463 observations over 1992-2008.

Many variables in our dataset may potentially be prone to measurement biases, which are quite standard in firm-level panel data of the FiBEn’s type. However, the originality of the FUDS proves useful to discuss some of its specific potential measurement issues. First, the questions asked in this survey are uncommon for managers. For this reason, small discrepancies are often not taken into account in the answers. In particular, we observe a lot of accumulation points for  $\Delta wk$ ,  $\Delta wl$  and  $\Delta CU$  (see Graph 1). We typically observe that: i) For a big proportion of observations, these variables do not change from one year to the next (these proportions being 61,6 %, 65,1 % and 38,2 % for respectively  $\Delta wk$ ,  $\Delta wl$  and  $\Delta CU$ ); ii) 11 ( $\Delta wk$ ), 12 ( $\Delta wl$ ) and 20 ( $\Delta CU$ ) modalities gather more than 1 % of the observations, and aggregating these modalities represents a large proportion of the sample (87,2 %, 90,8 % and 90,2 % for respectively  $\Delta wk$ ,  $\Delta wl$  and  $\Delta CU$ ). Second, working time measurement is particularly affected by several legal issues. Three notions of working time coexist in the French Labour Code: the legal working time over which hours worked benefit from overtime legal and conventional premiums; the contractual working time which is explicit in the individual labour contracts, and which can differ from the legal working time; and the effective working time which is factually respected and paid, and which can be superior to the contractual time. Plants can answer the survey using any of these three notions. In addition, during the period covered, the legal weekly working time were decreased from 39 to 35 hours in 2000 for firms of 20 employees or more, and in

<sup>5</sup> These plants are the ones usually covered by Banque de France monthly survey on business climate.

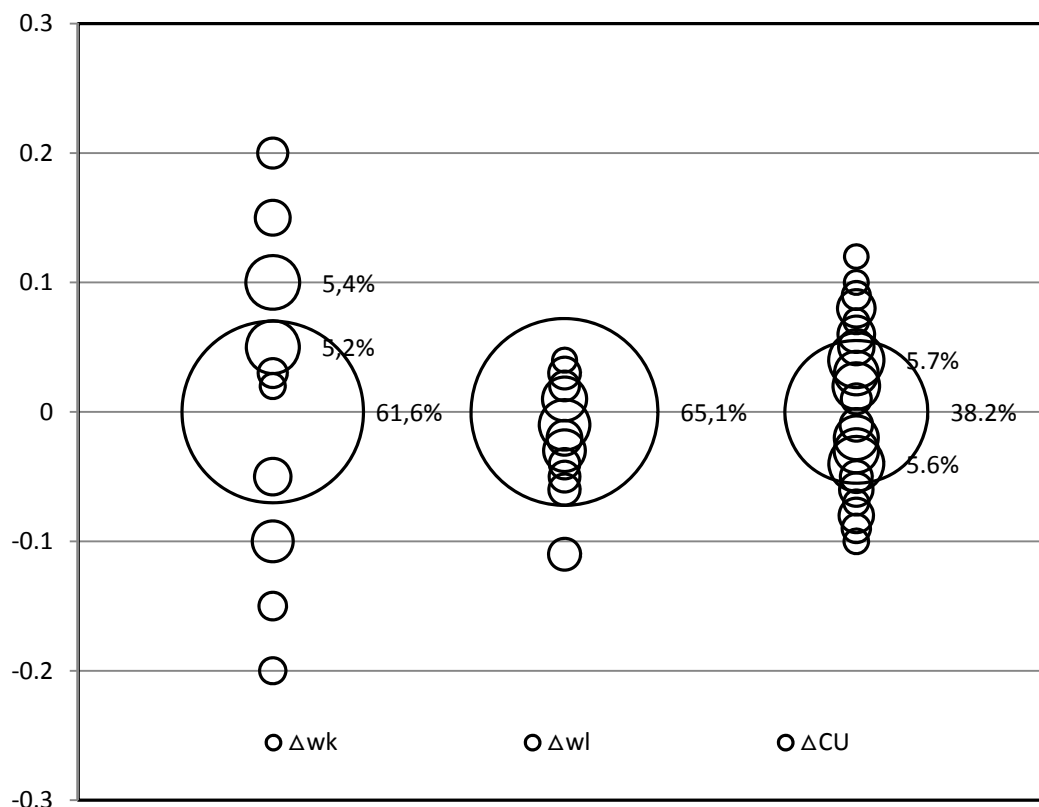
<sup>6</sup> In the final dataset, only 22 observations correspond to multi plants firms.

2002 for all other firms. For capital utilisation, an ambiguity may as well exist as the feasible production increase may be relative to the physical capacity of the equipments or relative to the sustainable profitability of the firm. These measurement problems will be dealt with using instrumental variables.

Some descriptive statistics are given for all variables in Appendix 1 (see Table A1.1).

Graph 1

**Accumulation points for the annual growth rates of capital workweek ( $\Delta wk$ ) and labour workweek ( $\Delta wl$ ), and the yearly changes in the capacity utilisation rate ( $\Delta CU$ )**  
All dataset (10,463 observations)



Note: Each circle corresponds to a modality gathering at least 1 % of observations. The center indicates the modality's value while the radius is proportional to the corresponding number of observations. The proportion in the 10,463 firms is reported next to the circle only when it is at least 5 %. For example, the annual growth rate of capital workweek ( $\Delta wk$ ) is nil for 61.6 % of firms, while the annual growth rate of labour workweek ( $\Delta wl$ ) is nil for 65.1 % of firms. The change in the capacity utilisation rate from one year to the next is nil for 38.2 % of firms.

### 3. The models

We define factor returns as the elasticity of output with respect to an aggregate volume of inputs. We first present the usual model (3.1.) then the model with utilisation degrees (3.2.), and the estimation strategy (3.3.).

#### 3.1. The usual model

We do not need to specify the production function and the substitution elasticity between inputs to measure factor returns. We only assume a two factor (capital and labour) production function and a Hicks-neutral technological progress:



$$Y_t = A_t F(L_t, K_{t-1}) \quad (1)$$

with  $Y_t$  the volume of value added;  $K_{t-1}$  the volume of capital stock available to produce during period  $t$ ,  $L_t$  the volume of labour and  $A_t$  a productivity scale factor.

Turning to logs (lower case), value added for firm  $i$ , in sector  $j$ , at date  $t$  can be written as:

$$y_{ijt} = a_{jt} + \lambda x_{ijt} + \mu_i + \xi_{jt} + \eta_{ijt} \quad (2)$$

where  $a_{jt}$  denotes total factor productivity for sector  $j$  at date  $t$ ,  $x_{ijt}$  the stock of production inputs, firm-fixed effect,  $\lambda$  corresponds to the returns to scale assumed to be the same for all firms,  $\mu_i$  captures unobserved heterogeneity between firms, time-and-sector-fixed effects  $\xi_{jt}$  controls for sectoral trends and cycles, and  $\eta_{ijt}$  is a white noise residual. We need this control for time and industry unobserved heterogeneity as relation between the output and the stock of production input depends on industry technology and may change over time.

Value added growth can therefore be estimated as:

$$\Delta y_{ijt} = \lambda \Delta x_{ijt} + \Delta v_{jt} + \varepsilon_{ijt} \quad (3)$$

where  $v_{jt} = a_{jt} + \xi_{jt}$  and  $\varepsilon_{ijt} = \Delta \eta_{ijt}$ . This sector-year fixed effect captures sector-specific business cycles but also potential externalities linked to the industry cycle<sup>7</sup>.

In each sector, we assume that the proportion of each input equals its value-added share and that these optimal factor shares do not change with scale. Hence, share-weighted factor growth can be written as:

$$\Delta x_{ijt} = \alpha_j \Delta l_{ijt} + (1 - \alpha_j) \Delta k_{ijt-1} \quad (4)$$

with  $\alpha_j$  the labour share in revenue for sector  $j$  (calculated from the median over firms in this industry, over our dataset period).

### 3.2. The model with utilisation degrees

Introducing utilisation degrees, the production function can then expressed as:

$$Y_t = A_t F(WL_t L_t, WK_t CU_t K_{t-1}) \quad (5)$$

with  $Y_t$  the volume of value added;  $K_{t-1}$  the volume of capital stock available to produce during period  $t$ ,  $L_t$  the volume of labour,  $A_t$  a productivity scale factor,  $CU_t$  the capacity utilisation rate,  $WL_t$  the labour workweek and  $WK_t$  the capital workweek. Changes in capacity utilisation may however correspond partially to changes in the workweek of capital rather than solely to an increase in the use of the capital stock  $K_{t-1}$ .

Turning to logs and differentiating, this relation becomes:<sup>8</sup>

$$\Delta y_{ijt} = \lambda \Delta x_{ijt} + \beta_{WK} \Delta wk_{ijt} + \beta_{WL} \Delta wl_{ijt} + \beta_{CU} \Delta CU_{ijt} + \Delta v_{jt} + \varepsilon_{ijt} \quad (6)$$

<sup>7</sup> We do not test directly this hypothesis contrary to Caballero and Lyons (1992) and Oulton (1996).

<sup>8</sup> Estimation in level is not possible as the workweek of capital in the FUDS is only available in changes from one year to the next.

According to (5), we may expect  $\beta_{WK} = \alpha_j$  and  $\beta_{WL} = \beta_{CU} = (1 - \alpha_j)$ . As emphasised above, ambiguities in the measurement of factor utilisation degrees lead us not to constraint these coefficients in our estimates.

If we estimate (3) instead of (6), a bias in the estimation of  $\lambda$  may appear, since changes in factor utilisation degrees ( $\Delta d$ ) are also a determinant of the explained variable  $\Delta y$ , and since it may be correlated with  $\Delta x$ . More precisely, two cases are possible. If  $\Delta x$  and  $\Delta d$  are positively correlated,  $\hat{\lambda} > \lambda$ , i.e. the estimated returns to scale will be biased upwards. On the other hand, if the correlation between  $\Delta x$  and  $\Delta d$  is negative, returns to scale will tend to be underestimated. Let us notice that this omitted variable bias will be equal to the weighted portion of  $\Delta d$  which is “explained” by  $\Delta x$ .

This omitted variable bias is in line with Shapiro (1993) or Basu (1996): short-run increasing returns usually estimated when factor utilisation degrees are not taken into account would disappear when degrees of factors utilisation are introduced. Besides, utilisation degrees may also be subject to a simultaneity bias. Unobserved productivity shocks may induce firms to adapt their input utilisation for a given demand, making utilisation endogenous and bringing another clear justification for the use of instrumental variables.

To sum up, including utilisation degrees appears fundamental to measure the “true” size of factors returns to scale. Moreover, a careful identification strategy for factor returns is necessary to avoid simultaneity biases.

### 3.3. Estimation strategy

Let us stress that, in contrast with Shapiro (1993) or Basu (1996), we estimate these relationships on firm-level panel data rather than at the industry average level. This makes room for studying the complexity of firm characteristics, which can diverge from industry characteristics, even in narrowly defined sectors.

The potential joint determination of inputs and production requires a control for the endogeneity of  $\Delta x$ . To this end, we choose to perform two-stage least squares (2SLS hereafter) regressions. The direction of the bias is unknown: an unobserved demand shock may lead to a joint increase in inputs and production, but an unobserved productivity shock may lead to an increase in production and a decrease in inputs.

Shapiro (1993) *only* used year dummies as instruments. Our objective is to undertake a careful identification strategy that tackles the aforementioned simultaneity bias, on the original French firm-level dataset presented in Section 2. Put differently, we want to test if apparent short-run increasing returns to scale disappear when input utilisation degrees are taken into account, in an approach designed so as to rule out potential endogeneity issues.

To deal with these simultaneity biases, and the potential endogeneity of  $\Delta x$ ,  $\Delta wk$ ,  $\Delta wl$  and  $\Delta CU$ , we adopt an instrumental variable approach. Our pool of instrument is the following:

- changes in capital and labour at the industry level ( $\Delta k_{ind}$  and  $\Delta l_{ind}$ ) in order to capture industry-specific cycle in factor level;
- dummies if the firm uses shiftwork or report barriers to increasing the capital workweek<sup>9</sup> ( $1_{SW}$  and  $1_{obst}$ ) in order to capture firm-specific leeway or impediment to changes in factor utilisation;

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<sup>9</sup> FUDS includes questions about barriers to increasing the capital workweek, which are analysed in a forthcoming paper of Cette, Dromel, Lecat and Paret.

- changes in the rate of employees organised in shift-work ( $SW^1$  and  $\Delta SW_{-1}^2$ ) in order to instrument changes in factor utilisation;
- for the relation (6) estimates only, we add as specific instruments the acceleration rate in the capital and labour workweek and in capital utilisation ( $\Delta\Delta wk, \Delta\Delta wl$  and  $\Delta\Delta CU$ ) in order to benefit from their statistical relationship with  $\Delta wk$ ,  $\Delta wl$  and  $\Delta CU$ .

To sum up, we mainly choose acceleration values, industry level statistics or shift-work rates as instruments, which can arguably be thought as exogenous with respect to contemporaneous value-added growth from a theoretical point of view. Moreover, the statistical relevance of these instruments is assessed through the traditional tests for overidentifying restrictions (Hansen), through a look at the stability of results and tests when removing instruments one by one (see 4.2 robustness checks) and through first-stage regressions estimates (see appendix 2).

As panel data may be subject to heteroscedasticity, we systematically use robust t-statistics. We introduce size dummies (cf. appendix 1) to control for different growth trends between small, medium and large firms due to convergence.

## 4. Estimation results

We first present the estimation results of the usual model and of the model with utilisation degrees (4.1.), and some robustness checks (4.2.).

### 4.1. Estimation results

Estimation results of the usual model without utilisation factor degrees (equation 3) are reported in Table 1, Column 1. 2SLS estimation strategy is relevant, since Wu-Hausman tests reject the null hypothesis of exogeneity for  $\Delta x$ . This suggests a joint determination of factor level and production. The Hansen test p-values allow us to consider that our instruments are valid and not correlated with the error term.

We estimate increasing returns to scale: the 1.46 coefficient of  $\Delta x$  (which is significantly above 1) means that if factors would expand by 1%, value added would increase by 1.46%. This is quite strong, but usual in this type of estimation.

Estimation results of the model with factor utilisation degrees are reported in Table 1, column 2. Here again, the Hansen test p-values allow us to consider that our instruments are valid and not correlated with the error term, while the Wu-Hausman tests confirm our instrumental variable strategy. The first-stage regressions are available in Appendix 2.

The introduction of factor utilisation is associated with a drop in the magnitude of the returns to scale. This corroborates the omitted-variable bias argument developed in the previous section: as changes in factor utilisation is significantly and positively correlated with changes in factor level (except for hours worked, which is not significantly correlated with factor level), omitting factor utilisation should bias upwards factor return to scale. When controlling for the omitted-variable and endogeneity bias,  $\lambda$  is not significantly different from 1; hence, the hypothesis that short-term returns are constant is not rejected, although the precise coefficient estimate points to small increasing returns (9.4%). This corroborates the results from Shapiro (1993) or Basu (1996), with a careful identification strategy on original French data *at the firm level*.

Factor utilisation contributes significantly to explain factor returns. This is particularly robust and relevant for the capital workweek: its coefficient is strongly significant; it is close to the expected

contribution of capital in a Cobb-Douglas constant return to scale production function. This is a strong confirmation of the important role of the capital workweek to explain factor returns. The capacity utilisation coefficient is significantly positive, but not very strong. This degree contributes to short run factor returns, but not as much as the capital workweek. The labour workweek is always positive, but not significant. As labour hours are technically linked to the capital workweek, it is hardly surprising that it is difficult to disentangle labour from capital workweek impact. Labour hours may also be badly measured as several labour workweek concepts coexist (cf. 2. above) and may give rise to a not-fully consistent reporting across firms.

One may wonder if the collinearity between factor utilisation degrees can bias the contribution of the labour workweek (which appears to be non significant) or of capacity utilisation (which is lower than expected). To answer this question we introduce separately then additively (with alternative combinations) factor utilisation degrees (cf. Table 2). Coefficients for capacity utilisation and the labour workweek would tend to be higher and more significant when the capital workweek is not introduced as a regressor, although they do not reach the expected levels. Interestingly, we would still be far from constant returns to scale when introducing them without the workweek of capital. This would suggest a low information content for the capacity utilisation and labour workweek variables, that can be due to a certain ambiguity in the way survey questions were asked. In contrast, the capital workweek keeps a significant and quite unchanged coefficient, and its inclusion always brings returns to scale close to one.

Table 1

**Measuring factors return to scale with and without factor utilisation degrees**Dependent variable:  $\Delta y$ 

	$\Delta y$	$\Delta y$
$\Delta x$	1.461*** (0.206)	1.094*** (0.205)
$\Delta CU$		0.0939** (0.0354)
$\Delta wl$		0.0830 (0.0535)
$\Delta wk$		0.315*** (0.0426)
Nb. Obs.	10463	10463
Test $\lambda = 1$		
P-value	0.0253	0.6467
Hansen J statistic	7.438	7.174
P-value	0.190	0.208
Wu-Hausman (F)	17.4679	4.73984
P-value	0.0000	0.0008
Instruments:	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$
Year*Industry & Size fixed effects	Yes	Yes
With correction for heteroscedasticity	Yes	Yes

Standard errors in parentheses

°  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ Hansen J statistic tests the validity of instrumental variables (overidentification test of all instruments). The null hypothesis  $H_0$  is that instruments as a group are exogenous.Wu-Hausman statistic tests the endogeneity of the instrumented variables. The null hypothesis  $H_0$  is that variables are exogenous.

Table 2

**Measuring factors return to scale with factor utilisation degrees**Dependent variable:  $\Delta y$ 

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta x$	1.461*** (0.206)	1.449*** (0.204)	1.457*** (0.206)	1.078*** (0.205)	1.446*** (0.204)	1.093*** (0.205)	1.080*** (0.205)	1.094*** (0.205)
$\Delta CU$		0.132*** (0.0369)			0.129*** (0.0368)	0.0962** (0.0354)		0.0939** (0.0354)
$\Delta wl$			0.109° (0.0567)		0.0971° (0.0563)		0.0905° (0.0536)	0.0830 (0.0535)
$\Delta wk$				0.338*** (0.0428)		0.318*** (0.0427)	0.334*** (0.0428)	0.315*** (0.0426)
Nb. Obs	10463	10463	10463	10463	10463	10463	10463	10463
Test $\lambda = 1$								
P-value	0.0253	0.0278	0.0264	0.7030	0.0289	0.6514	0.6960	0.6467
Hansen J statistic	7.438	6.859	7.177	7.671	6.653	7.341	7.471	7.174
P-value	0.190	0.231	0.208	0.175	0.248	0.196	0.188	0.208
Wu-Hausman (F)	17.4679	16.6371	10.9219	2.87875	12.0272	5.69905	2.86479	4.73984
P-value	0.0000	0.0000	0.0000	0.0562	0.0000	0.0007	0.0352	0.0008
Instruments:	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obs}$ $SW^1$ $\Delta SW_{-1}^2$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta wl$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$

Year\*industry &amp; Size fixed effects

Correction to heteroscedasticity

Standard errors in parentheses  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ Hansen J statistic tests the validity of instrumental variables (overidentification test of all instruments). The null hypothesis  $H_0$  is that instruments as a group are exogenous.Wu-Hausman statistic tests the endogeneity of the instrumented variables. The null hypothesis  $H_0$  is that variables are exogenous.

## 4.2. Robustness checks

Our results appear to be robust to several robustness checks. More precisely, we re-estimate equation (6), on different sub-periods, removing alternatively each of the production sectors and removing alternatively each instrumental variables.

Estimating on different sub-periods allows us to see if our results are neither due to specific trends on a particular sub-period or specific shocks, such as the changes in hours work regulation which occurred during this period.<sup>10</sup> Results on 1992-1999 and 2000-2008 are reported in Table 3, Columns 2 and 3: in both periods, factor returns are not significantly different from 1 and the capital workweek coefficient is significant and positive, around 0.3. Coefficients for capital utilisation and labour workweek are not as robust: they are both positive but not always significant.

Removing alternatively each of the production sectors, one by one, allows us to see if our results are due to heterogeneity between production sectors. Results are reported in Table 3, Columns 4 to 7. Once again, factor returns are never significantly different from 1 and elasticity to the capital workweek is significant and remains around 0.3. Capital utilisation and labour workweek coefficients are always positive but not always significant.

Removing alternatively each instrumental variables, one by one, allows us to test the robustness of our results to particular instruments. Coefficients may be less precise when removing relevant instruments but Hansen tests should remain valid if the exogeneity of our set of instruments is not driven by one particular variable. Results are reported in Table 4. The validity of instruments is never rejected. Returns to scale are never significantly different from one. Factor utilisation is almost always positive but not always significant, which could be expected as removing instruments lowers the precision of estimates.

To sum up, we get globally consistent results for all estimates. These checks show that constant returns to scale are robust to all tests (particularly, the test for  $\lambda=1$  is validated for every estimate), while the positive coefficient of the workweek of capital resists changes in periods or sample and most changes in instruments. Capital utilisation coefficient tends to be fairly robust, while the labour workweek coefficient is not.

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<sup>10</sup> The legal workweek was decreased stepwise from 39h to 35h, with a major step in 2000, leading us to favour this cut-off.

Table 3  
**Robustness** (Table 1, Column 2)  
Dependent variable:  $\Delta y$

		1.Period (before 1999)	2.Period (after 2000)	Without Food industries	Without Consumer Goods industries	Without Intermediat e Goods industries	Without Equipment Goods and Automobile industries
$\Delta x$	1.094*** (0.205)	1.133*** (0.255)	0.935** (0.298)	1.130*** (0.214)	1.079** (0.332)	1.064*** (0.241)	1.043*** (0.198)
$\Delta CU$	0.0939** (0.0354)	0.159*** (0.0465)	0.0281 (0.0519)	0.109** (0.0379)	0.123** (0.0407)	0.0643 (0.0438)	0.0667 (0.0410)
$\Delta wl$	0.0830 (0.0535)	0.0233 (0.0694)	0.174* (0.0824)	0.0653 (0.0561)	0.137* (0.0648)	0.111 (0.0701)	0.0316 (0.0577)
$\Delta wk$	0.315*** (0.0426)	0.288*** (0.0537)	0.355*** (0.0689)	0.335*** (0.0442)	0.336*** (0.0488)	0.279*** (0.0538)	0.294*** (0.0515)
Nb. Obs.	10463	6201	4262	9237	8335	5754	8063
Test $\lambda = 1$ P-value	0.6467	0.6005	0.8283	0.5434	0.8118	0.7913	0.8298
Hansen J statistic P-value	7.174 0.208	2.815 0.728	8.653 0.124	5.269 0.384	7.447 0.189	4.925 0.425	9.332 0.0965
Wu-Hausman (F) P-value	4.73984 0.0008	1.85154 0.1161	2.8484 0.0226	5.23209 0.0003	2.83144 0.0232	2.33907 0.0529	4.56791 0.0011
Instruments:	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind} \Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind} \Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind} \Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind} \Delta l_{ind}$ $1_{SW} 1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$

Standard errors in parentheses

$^{\circ} p < 0.10$ ,  $^* p < 0.05$ ,  $^{**} p < 0.01$ ,  $^{***} p < 0.001$

With Year\*Industry & Size fixed effects

With correction for heteroscedasticity

Hansen J statistic tests the validity of instrumental variables (overidentification test of all instruments). The null hypothesis  $H_0$  is that the instruments as a group are exogenous.

Wu-Hausman statistic tests the endogeneity of the instrumented variables. The null hypothesis  $H_0$  is that the variables are exogenous.



Table 4

**Robustness IV** (Table 1, Column 2)Dependent variable:  $\Delta y$ *IV removed one by one*

		Without $SW^1$	Without $\Delta SW_{-1}^2$	Without $1_{sw}$	Without $1_{obst}$	Without $\Delta k_{ind}$	Without $\Delta l_{ind}$	Without $\Delta \Delta wk$	Without $\Delta \Delta wl$	Without $\Delta \Delta CU$	
$\Delta x$		1.094*** (0.205)	1.113*** (0.204)	1.236*** (0.223)	1.175*** (0.225)	1.074*** (0.209)	1.087*** (0.206)	1.039*** (0.220)	1.087° (0.587)	1.224*** (0.294)	1.248*** (0.261)
$\Delta CU$		0.0939** (0.0354)	0.0947** (0.0356)	0.0970** (0.0357)	0.0949** (0.0356)	0.0934** (0.0355)	0.0939** (0.0354)	0.0927** (0.0353)	0.0933 (0.0658)	-0.0199 (0.0823)	1.329 (0.822)
$\Delta wl$		0.0830 (0.0535)	0.0810 (0.0534)	0.0793 (0.0546)	0.0818 (0.0539)	0.0831 (0.0533)	0.0829 (0.0534)	0.0841 (0.0530)	0.0827 (0.0587)	4.198° (2.456)	-0.0154 (0.0933)
$\Delta wk$		0.315*** (0.0426)	0.314*** (0.0427)	0.309*** (0.0435)	0.312*** (0.0433)	0.316*** (0.0425)	0.316*** (0.0427)	0.318*** (0.0425)	0.321 (0.502)	0.142 (0.117)	0.0710 (0.170)
N		10463	10463	10463	10463	10463	10463	10463	10463	10463	10463
$x = 1$ (or $\Delta x = 1$ )											
P-value		0.6467	0.5801	0.2900	0.4359	0.7228	0.6727	0.8585	0.8817	0.4457	0.3425
Hansen statistic	J	7.174	6.184	3.142	5.604	7.150	7.103	7.127	7.160	1.754	4.834
P-value		0.208	0.186	0.534	0.231	0.128	0.131	0.129	0.128	0.781	0.305
Wu-Hausman (F)		4.73984	4.86976	5.30445	5.06543	4.56142	4.66055	4.34231	4.71182	5.44394	2.88113
P-value		0.0008	0.0006	0.0003	0.0004	0.0011	0.0009	0.0016	0.0008	0.0002	0.0213
Instruments		$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$	$\Delta k_{ind}$ $\Delta l_{ind}$ $1_{sw}$ $1_{obst}$ $SW^1$ $\Delta SW_{-1}^2$ $\Delta \Delta CU$ $\Delta \Delta wl$ $\Delta \Delta wk$

Standard errors in parentheses °  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ 

With Year\*Industry &amp; Size fixed effects

With correction for heteroscedasticity

**5. Conclusion**

In this paper, we show the often-emphasized short-run increasing returns to scale actually stem from the omission of factor utilisation – capital workweek, labour working time and capacity utilisation. Although this conclusion was already felt by Solow (1973) and reached by Shapiro (1993) or Basu (1996), we strengthen their findings on firm-level data (in contrast with these two previous studies)

with direct measurement of factor utilisation degrees (in contrast with Basu, 1996), taking into account measurement and endogeneity biases, and using a unique survey on factor utilisation. We also show that capital workweek is the most significant determinant of factor utilisation, beyond labour hours or capital utilisation. These results are robust to a wide array of tests.

This important impact of factor utilisation is a potential bias for productivity estimates which do not take into account factor utilisation degrees – which are however scarcely available and often badly assessed. This explains the strong procyclicality of total factor productivity measures, which are yet supposed to account for structural efficiency. Without proper indicators for factor utilisation, the cycle should be carefully taken into account to get an accurate diagnosis on productivity dynamics.

Taking into account the degrees of factor utilisation, we still do not measure directly factor services, but go beyond gross factor stocks. As it is difficult to disentangle the measure of factor services from the efficiency of factor utilisation, our method seems the most appropriate to explain productivity and scale returns changes over the short run.

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## Appendix 1

### Data

Table A1.1

#### Descriptive Statistics

Variable	Description	Formule	Source	P10	Q1	Median	Q3	P90	Mean	Standard Error
y	Value added	$\ln(Y)$	FiBEn	7.007	7.558	8.352	9.270	10.100	8.463	0.012
x	Conventional input	$x = \alpha \ln(K_{-1}) + (1 - \alpha) \ln(L)$	FiBEn	4.205	4.743	5.522	6.372	7.201	5.619	0.011
$\Delta va$	Value added growth rate		FiBEn	-0.180	-0.072	0.019	0.106	0.203	0.010	0.002
$\Delta x$	Growth rate of conventional inputs		FiBEn	-0.073	-0.028	0.005	0.042	0.091	0.007	0.001
$\Delta wk$	Growth rate of the workweek of capital (capital operating time)		FUDS	-0.050	0.000	0.000	0.000	0.100	0.011	0.001
CU	Capacity utilisation rate		FUDS	0.714	0.800	0.870	0.909	0.962	0.852	0.001
$\Delta CU$	Variation of the capacity utilisation rate		FUDS	-0.082	-0.030	0.000	0.031	0.076	-0.001	0.001
WL	Workweek of labour	In hours per week	FUDS	35.000	35.000	38.500	39.000	39.500	37.647	0.022
$\Delta wl$	Growth rate of the workweek of labour		FUDS	-0.044	0.000	0.000	0.000	0.013	-0.005	0.000

FUDS : Factor Utilisation Degrees Survey

Firm's size dummies	Firm's size, based on the workforce	3 classes :	Frequency	Percentage
$1_{size 1}$		1- workforce < 50	2904	27.7
$1_{size 2}$		2- 50 ≤ workforce < 250	5216	49.9
$1_{size 3}$		3- workforce ≥ 250	2343	22.4

## Appendix 2

Table A2.1

### First-stage regressions (Table2, Column 2)

To save on space, industry\*year and size fixed-effects coefficients do not appear here, even if they take part in these first stage regressions.

$\Delta x$	<i>coefficient</i>	<i>standard error</i>	<i>p-value</i>
$\Delta k_{ind}$	0.1446	0.1898	0.446
$\Delta l_{ind}$	0.8777***	0.2159	0.000
$1_{sw}$	0.0071**	0.0022	0.001
$1_{obst}$	0.0057**	0.0018	0.002
$SW^1$	0.0052	0.0080	0.519
$\Delta SW^2_{-1}$	0.0252**	0.0094	0.007
$\Delta \Delta CU$	-0.0099	0.0078	0.204
$\Delta \Delta wl$	0.0084	0.0126	0.503
$\Delta \Delta wk$	0.0222*	0.0098	0.024

F-test of excluded instruments : 11.34

Prob > F: 0.0000

$\Delta wl$	<i>coefficient</i>	<i>standard error</i>	<i>p-value</i>
$\Delta k_{ind}$	0.0512	0.0377	0.174
$\Delta l_{ind}$	-0.0053	0.0534	0.921
$1_{sw}$	0.0004	0.0006	0.458
$1_{obst}$	0.0011*	0.0005	0.026
$SW^1$	-0.0059*	0.0023	0.011
$\Delta SW^2_{-1}$	-0.0022	0.0025	0.383
$\Delta \Delta CU$	0.0017	0.0022	0.445
$\Delta \Delta wl$	0.5011***	0.0085	0.000
$\Delta \Delta wk$	0.0067**	0.0024	0.006

F-test of excluded instruments : 396.45

Prob > F: 0.0000

$\Delta wk$	<i>coefficient</i>	<i>standard error</i>	<i>p-value</i>
$\Delta k_{ind}$	-0.0761	0.1664	0.647
$\Delta l_{ind}$	0.9969***	0.1845	0.000
$1_{sw}$	0.0096***	0.0014	0.000
$1_{obst}$	0.0097***	0.0013	0.000
$SW^1$	0.0046	0.0083	0.575
$\Delta SW^2_{-1}$	0.0274***	0.0075	0.000
$\Delta \Delta CU$	-0.0161*	0.0069	0.020
$\Delta \Delta wl$	-0.0133	0.0121	0.272
$\Delta \Delta wk$	0.5107***	0.0153	0.000

F-test of excluded instruments : 168.67

Prob > F: 0.0000

$\Delta CU$	<i>coefficient</i>	<i>standard error</i>	<i>p-value</i>
$\Delta k_{ind}$	-0.1235	0.0898	0.169
$\Delta l_{ind}$	0.2092°	0.1108	0.059
$1_{sw}$	-0.0009	0.0011	0.397
$1_{obst}$	0.0037***	0.0010	0.000
$SW^1$	0.0059	0.0046	0.199
$\Delta SW^2_{-1}$	0.0053	0.0047	0.260
$\Delta \Delta CU$	0.4974***	0.0073	0.000
$\Delta \Delta wl$	-0.0055	0.0082	0.503
$\Delta \Delta wk$	0.0275***	0.0054	0.000

F-test of excluded instruments : 551.72

Prob > F: 0.0000

°  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$